Multifamily Low-rise

GENERAL DESCRIPTION

The multifamily low-rise prototype is intended to represent a 100% affordable housing multifamily building. It is a 5-story building with podium on the ground floor consisting of a residential lobby and back of house spaces as well as an unconditioned above grade parking garage. 58 apartments are on floors 2 through 5 in a double loaded corridor configuration.

The building geometry has been defined to be representative for the State of Massachusetts. The multifamily low-rise geometry includes **62,300 gross sf** in four (4) residential stories above grade plus an above grade residential lobby / back of house ground floor adjacent to an above grade parking garage on the ground floor. The building is slab on-grade. There are six (6) variations of this building typology defined as follows:

2018 IECC (Gas-Heat & DHW): Multifamily low-rise Base Case Scenario is a **code-compliant building**. This building is expected to meet all code requirements of IECC 2018 prescriptive path and current MA amendments. Primary heating for the building is gas-fired water heaters tied to air handlers in each apartment via a combination unit plus gas fired furnaces for air delivered to common spaces. Primary DHW for the building is in-unit gas-fired water heaters.

2018 IECC (All Electric): Multifamily low-rise Base Case Scenario is a **code-compliant building**. This building is expected to meet all code requirements of IECC 2018 prescriptive path and current MA amendments. Primary heating for the building is provided via one-to-one heat pumps. Primary DHW for the building is in-unit electric tank water heaters.

2021 IECC (Gas-Heat & DHW): Multifamily low-rise Base Case Scenario is a future **code-compliant building**. This building is expected to meet all code requirements of IECC 2021 prescriptive path and both current and future MA amendments. Primary heating for the building is in-unit gas-fired water heaters tied to air handlers in each apartment via a combination unit plus gas fired furnaces for air delivered to common spaces. Primary DHW for the building is in-unit gas-fired water heaters.

2021 IECC (All Electric): Multifamily low-rise Base Case Scenario is a future **code-compliant building**. This building is expected to meet all code requirements of IECC 2021 prescriptive path and both current and future MA amendments. Primary heating for the building is provided via one-to-one heat pumps. Primary DHW for the building is in-unit electric tank water heaters.

Passive House (Electric Heat, Gas-DHW): This building is expected to exceed current Stretch Energy Code requirements including MA amendments. Primary heating for the building is a one-to-one heat pumps in each apartment. Primary DHW for the building is in-unit gas tank water heaters.

Passive House (All Electric): This building is expected to exceed current Stretch Energy Code requirements including MA amendments. Primary heating for the building is a one-to-one heat pumps in each apartment. Primary DHW for the building is in-unit electric tank water heaters.

BUILDING ENVELOPE

The exterior envelope consists of cold formed steel framed back up walls with a metal panel rainscreen facade, built-up roof, and slab on grade assemblies.

Envelope System	Gross Area (GSF)	Net Area (SF)
Above Grade Wall	31,596	25,937
Windows		Total = 5,659 (18% WWR) Punched Fixed = 2762 Punched Operable = 2,638 Storefront = 259
Opaque Doors		300
Roof		15,391
Parking Garage Ceiling		11,511
Slab On Grade		In Conditioned Space = 3,880 Unconditioned Space (Parking) = 11,511

A. Above Grade Exterior Wall: The multifamily low-rise prototype assumes a 2x6 (16" on center) wood framed construction with a metal panel rain screen façade system for all cases. The table below summarizes design differences among the various scenarios.

IECC 2018 Cases (gas heat / DHW & all electric)
Façade Attachment: non-thermally broken clip system Exterior Insulation: 2" of mineral wool Cavity Insulation: R-13 batt insulation *Effective Assembly R-value = R-17 *with thermal bridging accounted for*
IECC 2021 Cases (gas heat / DHW & all electric)
Façade Attachment: non-thermally broken clip system Exterior Insulation: 3" of mineral wool Cavity Insulation: R-13 batt insulation *Effective Assembly R-value = R-19 *with thermal bridging accounted for*
Passive House Cases (gas DHW & all electric)
Façade Attachment: fiberglass girt system (ie. GreenGirts) Exterior Insulation: 5" of mineral wool Cavity Insulation: R-23 batt insulation *Effective Assembly R-value = R-40 *with thermal bridging accounted for*

A. Roof:
   i. **IECC 2018 and IECC 2021 Cases**: Built-up roof with roof membrane, R-30 insulation, composite metal decking. Assembly effective R-value = R-25 when thermal bridging is accounted for.
   ii. **Passive House**: Built-up roof with roof membrane, R-65 insulation, composite metal decking. Thermal bridge mitigation with thermal isolation pads at mechanical dunnage and parapet structural thermal breaks. Assembly effective R-value = R-60 when thermal bridging is accounted for.

B. Parking Ceiling Slab:
   i. **IECC 2018 Cases** – concrete slab with R-12.5 continuous closed cell spray foam underneath slab.
   ii. **IECC 2021 Cases** – poured in place concrete foundation wall with R-16.7 continuous closed cell spray foam underneath slab.

iii. **Passive House Cases** – poured in place concrete foundation wall with R-40 continuous closed cell spray foam underneath slab.

C. Slab On Grade:

i. **IECC 2018 & 2021 Cases** – concrete slab with R-15 perimeter insulation installed vertically a minimum of 36" below grade. R-5 rigid insulation underneath the slab.

ii. **Passive House Cases** – concrete slab with R-15 perimeter insulation installed vertically a minimum of 36" below grade. R-15 rigid insulation underneath the slab.

D. Windows:

IECC 2018 Cases (gas heat / DHW & all electric)

Punched windows – 5,401 SF (36% fixed, 64% operable)
- Average double-glazed, uPVC frame
  o Operable U-value = 0.45
  o Fixed U-value = 0.38
  o Center of Glass SHGC = 0.35
Storefront windows – 259 SF (all fixed w/ exception of entry door)
- Good double-glazed, thermally broken aluminum frame, U-value = 0.38
- Center of Glass SHGC = 0.35

IECC 2021 Cases (gas heat / DHW & all electric)

Punched windows – 5,401 SF (36% fixed, 64% operable)
- Good double-glazed, uPVC frame
  o Operable U-value = 0.45
  o Fixed U-value = 0.36
  o Center of Glass SHGC = 0.35
Storefront windows – 259 SF (all fixed w/ exception of entry door)
- Good double-glazed, thermally broken aluminum frame, U-value = 0.38
- Center of Glass SHGC = 0.35

Passive House Cases (gas DHW & all electric)

Punched windows – 5,401 SF (36% fixed, 64% operable)
- Great triple-glazed, uPVC frame
  o Operable U-value = 0.16
  o Fixed U-value = 0.14

- Center of Glass SHGC = 0.40

Storefront windows – 259 SF (all fixed w/ exception of entry door)

- Good double-glazed, thermally broken aluminum frame, U-value = 0.38
- Center of Glass SHGC = 0.40

E. Infiltration: Whole building air infiltration rates are:
   i. **IECC 2018 Cases** – 0.40 CFM / SF @ 75 Pa.
      i. No whole building air-leakage testing.
   ii. **IECC 2021 Cases** – 0.25 CFM / SF @ 75 Pa.
      i. In order to achieve this level of air leakage performance, a scope for basic envelope commissioning.
   iii. **Passive House Cases** - 0.09 CFM / SF @ 75 Pa (0.6 ACH50)
      i. In order to achieve this level of air leakage performance, a scope for enhanced envelope commissioning and whole building air leakage testing should be assumed.

STRUCTURAL SYSTEM

Wood-framed construction; 201' X 120' T-shaped building with 5 floors above grade plus an interior conditioned rooftop mechanical penthouse:

- Ground floor = 13' 4"
- Typical floors 2 through 5 = 9' 8"
- Bulkhead = 13' 4"

All applicable codes and load criteria should be applied.

MECHANICAL SYSTEM

DESCRIPTION

A. **IECC 2018 Case (Gas Heat & DHW):** Gas-fired combination units in each apartment provide hot water for space heating to an air handler (on per apt.) with a heating efficiency of 88%. Cooling is provided via DX cooling coils in each apartment's AHU with a SEER of 16.5. The outdoor condensing units are located either on the roof or in the above grade unconditioned parking garage. Domestic hot water is also provided via the combination units with a minimum heating efficiency of 88%. Common areas are heated via 80% efficient gas furnaces and cooled via DX cooling coils with a SEER of 16.5. Air is exhausted from each apartment directly to the exterior with makeup air vents being provided in each apartment at the exterior façade. All corridors, amenity, and back of house spaces are ventilated to code minimum rates with a heat recovery efficiency of 55%.

B. **IECC 2018 Case (All Electric):** One to one heat pumps for space heating and cooling are provided in each apartment (one per apt.) with a heating COP of 2.6 and a cooling SEER of 16.5. Common spaces are heated via electric furnaces and DX cooling coils with a SEER of 16.5. Domestic water heating is provided via in each unit via a 50-gallon electric resistance water

heater. Air is exhausted from each apartment directly to the exterior with makeup air vents being provided in each apartment at the exterior façade. All corridors, amenity, and back of house spaces are ventilated to code minimum rates with a heat recovery efficiency of 55%.

C. **IECC 2021 Case (Gas Heat & DHW):** Exactly the same as the IECC 2018 (Gas Heat & DHW) case.

D. **IECC 2021 Case (All Electric):** Exactly the same as the IECC 2018 (All Electric) case.

E. **Passive House (Electric Heat, Gas DHW):** Space heating and cooling is provided in each apartment via one-to-one heat pumps located in each apartment (one per apt.) with a heating COP of 2.6 and a cooling SEER of 16.5. Space heating and cooling is provided via DX heating and cooling coils in the common area ERVs with a heating COP of 2.6 and a cooling SEER of 16.5. Domestic water heating is provided via a 50-gallon gas fired condensing water heater in each apartment with a nominal efficiency of 95%. Ventilation is provided to each apartment via an in-unit energy recovery ventilator with a heat recovery efficiency of 85%. All corridors, amenity, and back of house spaces are ventilated to code minimum rates with a heat recovery efficiency of 85%.

F. **Passive House (All Electric):** Exactly the same as the Passive House (Electric Heat, Gas DHW) case with the one exception that domestic water heating is provided via a 50-gallon electric resistance water heater in each unit. A small photovoltaic array is provided to help offset a small portion of the building's electrical load.

MECHANICAL DESIGN CRITERIA:

The following mechanical design criteria is for reference only.

1. Space temperature and Humidity
    a. Summer: 75F, 55% RH maximum
    b. Winter: 70F
2. Ambient design Conditions
    a. Summer: 87F DB; 71F WB
    b. Winter: 7F
3. Ventilation
    a. Apartment Exhaust: 25 CFM per kitchen + 20 CFM per bathroom
        i. A unitized ventilation strategy is assumed for all cases
        ii. **IECC 2018 and IECC 2021 cases** - 65 CFM for 3-bed room apartments, 45 CFM in all other apartments, all exhaust air ducted directly to exterior w/ MUA provided via through wall vents in each apartment.

iii. **PH cases** – 65 CFM for 3-bed room apartments, 45 CFM in all other apartments, all exhaust air and outdoor provided via a unitized ERV.

b. Common Areas: ASHRAE minimum by space type

4. Filtration**:** MERV 6 pre-filters and MERV-14 final filters
5. Noise: All MEP systems shall be designed to maximum 40dBA permissible background noise.
6. Unit Mix
    a. Studios = 4 (each unit contains 1 bathroom)
    b. 1 BR = 25 (each unit contains 1 bathroom)
    c. 2 BR = 25 (each unit contains 1 bathroom)
    d. 3 BR = 4 (each unit contains 2 bathrooms)
7. Common Areas - total area = 15,740 SF
    a. Corridors / stairwells / transition areas = 5,600 SF
    b. Lobby = 1,500 SF
    c. Back of House = 5,904 SF
8. Occupancy – 149 total. According to RESNET (# of bedrooms + 1, studios count as one bedroom in occupancy calc.
9. Building peak total space heating load
    a. **Base Cases IECC 2018** = 807,000 Btu/hr
    b. **Base Cases IECC 2021** = 675,000 Btu/hr
    c. **Passive House Cases** = 244,000 Btu/hr
10. Building peak total space cooling load (sensible + latent)
    a. **Base Cases IECC 2018** = 1,413,000 Btu/hr
    b. **Base Cases IECC 2021** = 1,361,000 Btu/hr
    c. **Passive House Cases** = 867,000 Btu/hr
11. Domestic hot water consumption – 15 gallons of hot water per person per day. “Hot water” refers to water @ 140 degF.
12. Apartment Loads
    a. Miscellaneous Loads – 0.62 Watts/sf of dwelling area
    b. Refrigerators – 1 per apt. Energy Star
    c. Dishwashers – 1 per apt. Energy Star
    d. In-Unit Clothes Dryer – 1 per apt. Energy Star. Electric ventless condensing dryer.
    e. In Unit Clothes Washer – 1 per apt. Energy Star. Hot water feed from DHW system.
    f. Cooking – Electric conduction range
    g. Lighting – 1.1 Watts/sf of dwelling area
13. Common Loads
    a. Common Clothes Dryers – 23 total. Electric resistance direct exhaust with dedicated make up air to dryer room(s).

b. Common Clothes Washers – 23 total. Energy Star. Hot water
c. Lighting & Plugs
    i. Corridors / stairwells / transition areas = 5,600 SF @ 0.66 Watts/SF
    ii. Lobby = 1,500 SF @ 1.00 Watts/SF
    iii. Back of House = 5,904 SF @ 0.43 Watts/SF

14. Duct leakage
    a. **IECC 2018 and IECC 2021 Cases**: All ductwork to be sealed according to mechanical code requirements.
    b. **Passive House Cases**: All ductwork to be sealed according to mechanical code requirements. Additional scope estimated at $5,000 should be included to allow for additional oversight and inspections of the in-unit duct sealing. In addition, all ventilation air ductwork tied to the common area ERV is to be Aerosealed. An Aersoseal specification can be found here - https://aeroseal.com/wp-content/uploads/2018/05/aeroseal-com-specs-180522.pdf

HEATING & COOLING SYSTEMS

IECC 2018 (Gas Heat and DHW) Case:

Combination units connected to gas fired 50-gallon water heaters (one per apt.) with an efficiency of 88% provide hot water for space heating to the air handling units located in each apartment. Cooling is provided to each apartment via DX cooling coils located in each apartment's air handling unit with a cooling SEER of 16.5. The outdoor condensing units for these DX coils are located either on the roof of the building or in the building's unconditioned above grade parking garage on the ground floor.

- Studios – Combination unit space heating = 6,000 BTUH / DX cooling = 10,000 BTUH (incl. latent)
- 1 BR – Combination unit space heating = 12,000 BTUH / DX cooling = 16,000 BTUH (incl. latent)
- 2 BR – Combination unit space heating = 14,000 BTUH / DX cooling = 22,000 BTUH (incl. latent)
- 3 BR – Combination unit space heating = 20,000 BTUH / DX cooling = 28,000 BTUH (incl. latent)

Common spaces will be heated via an 88% efficient gas-fired furnace in the common area AHU with a heating capacity of 180,000 BTUH. Common spaces are cooled via DX cooling coils in the common area AHU connected to outdoor condensing units with a cooling SEER of 16.5 and a cooling capacity of 300,000 BTUH.

IECC 2018 (All Electric) Case:

One-to-one heat pumps in each apartment provide space heating and cooling to each apartment. The heat pumps have a heating COP of 2.6 and a cooling SEER of 16.5. The outdoor condensing units for these one-to-one heat pumps are located either on the roof of the building or in the building's unconditioned above grade parking garage on the ground floor.

- Studios – 1-1 HP space heating = 11,000 BTUH / 1-1 HP cooling = 10,000 BTUH (incl. latent)
- 1 BR – 1-1 HP space heating = 18,000 BTUH / 1-1 HP cooling = 16,000 BTUH (incl. latent)
- 2 BR – 1-1 HP space heating = 25,000 BTUH / 1-1 HP cooling = 22,000 BTUH (incl. latent)
- 3 BR – 1-1 HP space heating = 32,000 BTUH / 1-1 HP cooling = 28,000 BTUH (incl. latent)

Common spaces will be heated via an electric furnace in the common area AHU with a heating capacity of 180,000 BTUH. Common spaces are cooled via DX cooling coils in the common area AHU connected to outdoor condensing units with a cooling SEER of 16.5 and a cooling capacity of 300,000 BTUH

IECC 2021 Case (Gas Heat and DHW):

Combination units connected to gas fired 50-gallon water heaters (one per apt.) with an improved efficiency of 88% provide hot water for space heating to the air handling units located in each apartment. Cooling is provided to each apartment via DX cooling coils located in each apartment's air handling unit with a cooling SEER of 16.5. The outdoor condensing units for these DX coils are located either on the roof of the building or in the building's unconditioned above grade parking garage on the ground floor.

- Studios – Combination unit space heating = 6,000 BTUH / DX cooling = 10,000 BTUH (incl. latent)
- 1 BR – Combination unit space heating = 10,000 BTUH / DX cooling = 16,000 BTUH (incl. latent)
- 2 BR – Combination unit space heating = 12,000 BTUH / DX cooling = 22,000 BTUH (incl. latent)
- 3 BR – Combination unit space heating = 18,000 BTUH / DX cooling = 28,000 BTUH (incl. latent)

Common spaces will be heated via an 88% efficient gas-fired furnace in the common area AHU with a heating capacity of 160,000 BTUH. Common spaces are cooled via DX cooling coils in the common area AHU connected to outdoor condensing units with a cooling SEER of 16.5 and a cooling capacity of 300,000 BTUH.

IECC 2021 (All Electric) Case:

One-to-one heat pumps in each apartment provide space heating and cooling to each apartment. The heat pumps have an improved heating COP of 2.6 and cooling SEER of 16.5. The outdoor condensing units for these one-to-one heat pumps are located either on the roof of the building or in the building's unconditioned above grade parking garage on the ground floor.

- Studios – 1-1 HP space heating = 11,000 BTUH / 1-1 HP cooling = 10,000 BTUH (incl. latent)
- 1 BR – 1-1 HP space heating = 18,000 BTUH / 1-1 HP cooling = 16,000 BTUH (incl. latent)
- 2 BR – 1-1 HP space heating = 25,000 BTUH / 1-1 HP cooling = 22,000 BTUH (incl. latent)
- 3 BR – 1-1 HP space heating = 32,000 BTUH / 1-1 HP cooling = 28,000 BTUH (incl. latent)

Common spaces will be heated via an electric furnace in the common area AHU with a heating capacity of 160,000 BTUH. Common spaces are cooled via DX cooling coils in the common area AHU connected to outdoor condensing units with an improved cooling SEER of 16.5 and a cooling capacity of 300,000 BTUH

Passive House Cases:

One-to-one heat pumps in each apartment provide space heating and cooling to each apartment. The heat pump have a heating COP of 2.3 and a cooling SEER of 15.0. The outdoor condensing units for these one-to-one heat pumps are located either on the roof of the building or in the building's unconditioned above grade parking garage on the ground floor.

- Studios – 1-1 HP space heating = 9,000 BTUH / 1-1 HP cooling = 8,000 BTUH (incl. latent)
- 1 BR – 1-1 HP space heating = 11,000 BTUH / 1-1 HP cooling = 10,000 BTUH (incl. latent)
- 2 BR – 1-1 HP space heating = 16,000 BTUH / 1-1 HP cooling = 14,000 BTUH (incl. latent)
- 3 BR – 1-1 HP space heating = 20,000 BTUH / 1-1 HP cooling = 18,000 BTUH (incl. latent)

Common spaces will be heated and cooled via two primary systems:

- DX heating and cooling coil in the common area ERV with a heating capacity of 60,000 BTUH & heating COP = 2.6 and a cooling capacity of 80,000 BTUH & cooling SEER = 16.5.
- Additional cooling capacity is provided via ducted heat pumps with a total cooling capacity of 120,000 BTUH.

AIR HANDLERS

IECC 2018 Case (Gas Heat and DHW):

Each apartment is continuously exhausted at a rate of 25 CFM per kitchen + 20 CFM per bathroom and should comply with code minimum requirements. The apartment exhaust is vented directly to the exterior with make-up air vents provided at the exterior façade in each apartment. An air handler unit is located in each apartment (one per apt.) to recirculate air for space heating and cooling.

Air Handler	# of units	Supply Flow rate (cfm)	Outdoor Air flow rate (cfm)	Htg. Coil Capacity (BTU/h)	Clg. Coil Capacity (BTU/h)	Unit type/ Efficiency

Studio AHU	**4**	**800**	**0**	**18,800**	**18,000**	**HW coil, CW coil**
1 BR AHU	**25**	**800**	**0**	**18,800**	**18,000**	**HW coil, CW coil**
2 BR AHU	**25**	**800**	**0**	**24,700**	**24,000**	**HW coil, CW coil**
3 BR AHU	**4**	**1,000**	**0**	**28,300**	**30,000**	**HW coil, CW coil**

Common areas are to receive constant balanced ventilation through an ERV according to code minimum rates. The supply and exhaust fans in the ERV are to be equipped with variable frequency drives to maintain a constant flow of air to the building. A gas-fired furnace and DX cooling coil is provided in each ERV to temper supply air to room neutral temperatures before it is delivered to the building. The ERV is provided with a 100% economizer to directly bring in outdoor air when free cooling potential exists.

All ductwork is to be sealed to industry standard minimum levels and limit duct leakage to 10%. All ductwork is assumed to have fire dampers at all locations where required by code.

Air Handler	# of units	Supply Flow rate (cfm)	Outdoor Air flow rate (cfm)	Htg. Furnace Capacity (BTU/h)	Clg. Coil Capacity (BTU/h)	Unit type/ Efficiency	Economizer	Sensible Energy Recovery Eff.	Total Fan Eff. (Watts/CFM)
Common Area AHU	**1**	**10,500**	**2,000**	**180,000**	**300,000**	**HW coil, CW coil**	**Yes**	**55%**	**1.00**

IECC 2018 Case (All Electric):

Exactly the same as the IECC 2018 (Gas Heat and DHW) case with the following exceptions:

- There are no air handler units for space heating and cooling in the apartments as one to one heat pumps are providing heating and cooling to each apartment.
- The heating furnace in the common area AHU is an electric furnace with no change to its heating capacity.

IECC 2021 Case (Gas Heat and DHW):

Exactly the same as the IECC 2018 (Gas Heat and DHW) case with the one exception of the heating furnace capacity in the common area AHU as indicated in the table below.

Air Handler	# of units	Supply Flow rate (cfm)	Outdoor Air flow rate (cfm)	Htg. Furnace Capacity (BTU/h)	Clg. Coil Capacity (BTU/h)	Unit type/ Efficiency	Economizer	Sensible Energy Recovery Eff.	Total Fan Eff. (Watts/CFM)
Common Area AHU	**1**	**10,500**	**2,000**	**160,000**	**300,000**	**HW coil, CW coil**	**Yes**	**55%**	**1.00**

IECC 2021 Case (All Electric):

Exactly the same as the IECC 2018 (All Electric) case with the one exception that the electric furnace in the common area AHU has a reduced heating capacity of 160,000 BTUH.

Passive House (Electric Heat and Gas DHW):

Each apartment is continuously exhausted at a rate of 25 CFM per kitchen plus 20 CFM per bathroom and comply with code minimum requirements. One ERV is provided for each apartment. The apartment exhaust goes through the apartment ERV and equal outdoor air is supplied to each apartment via this ERV.

Common areas are to receive constant balanced ventilation through an ERV according to code minimum rates. The supply and exhaust fans in the ERV are to be equipped with variable frequency drives to maintain a constant flow of air to the building. A DX heating and cooling coil is provided in each ERV to temper supply air to room neutral temperatures before it is delivered to the building. The ERV is provided with a 100% economizer to directly bring in outdoor air when free cooling potential exists.

All common area ductwork is to be sealed to industry standard minimum levels plus receive additional air sealing via the Aeroseal process to limit duct leakage to 3% maximum. All ductwork is assumed to have fire dampers at all locations where required by code.

Air Handler	# of units	Supply Flow rate (cfm)	Outdoor Air flow rate (cfm)	Htg. Coil Capacit	Clg. Coil Capacit	Unit type/	Economize r	Sensible Energy	Total Fan Eff. (Watts/CFM)

					y (BTU/h)	y (BTU/h)	Efficiency		Recovery Eff.	
Studio ERV	**4**	**45**	**45**	**-**	**-**	**-**	**Yes**	**85%**	**0.80**	
1 BR ERV	**25**	**45**	**45**	**-**	**-**	**-**	**Yes**	**85%**	**0.80**	
2 BR ERV	**25**	**45**	**45**	**-**	**-**	**-**	**Yes**	**85%**	**0.80**	
3 BR ERV	**4**	**65**	**65**	**-**	**-**	**-**	**Yes**	**85%**	**0.80**	
Common ERV		**1**	**2,000**	**2,000**	**60,000**	**80,000**	**HW coil, CW coil**	**Yes**	**85%**	**0.80**

Passive House (All Electric):

Exactly the same as the Passive House (Electric Heat and Gas DHW) case.

ELECTRICAL SYSTEMS

Total Transformer loads:

- **IECC 2018 (Gas-Heat & DHW):** 348 kVA
- **IECC 2018 (All Electric):** 654 kVA
- **IECC 2021 (Gas-Heat & DHW):** 343 kVA
- **IECC 2021 (All Electric):** 652 kVA
- **Passive House (Elec-Heat & Gas DHW):** 355 kVA
- **Passive House (All Electric):** 622 kVA

A. Lighting and Electrical system controls are required to meet IECC2018 with MA Amendments. Standard code compliant lighting controls - Occupancy, vacancy sensors and daylighting controls are to be provided in common areas

DOMESTIC WATER / PLUMBING SYSTEMS

All plumbing fixtures are to be low flow fixtures. All cases are assumed to have a unitized domestic water heating (DHW) system. Total DHW piping is estimated to be 7,540 linear feet and is insulated to code minimum levels.

IECC 2018 (Gas Heat and DHW):

Domestic water heating will be provided via 50-gallon gas fired water heaters with an efficiency of 88% located in each apartment.

IECC 2018 (All Electric):

Domestic water heating will be provided via 50-gallon electric resistance water heating tanks.

IECC 2021 (Gas Heat and DHW):

Domestic water heating will be provided via 50-gallon gas fired water heaters with an efficiency of 88% located in each apartment.

IECC 2021 (All Electric):

Domestic water heating will be provided via 50-gallon electric resistance water heating tanks.

Passive House (Electric Heat, Gas DHW):

Domestic water heating will be provided via 50-gallon gas fired water heaters with an efficiency of 88% located in each apartment.

Passive House (All Electric):

Domestic water heating will be provided via 50-gallon electric resistance water heating tanks.

RENEWABLE ENERGY

No renewable energy systems are assumed in the IECC 2018 (All Electric), IECC 2021 cases, and Passive House (Electric Heat Gas DHW) case.

IECC 2018 (Gas Heat & DHW): A 10 kW photovoltaic located on site to meet the requirements of IECC 2018 C406.5.

Passive House (All Electric): A 25 kW photovoltaic located on site is provided to meet the PH source energy demand requirement.